XC6401 Series

Dual LDO Regulators, Low ESR Cap. Compatible

■GENERAL DESCRIPTION

The XC6401 series are highly accurate, Dual, low noise, CMOS LDO voltage regulators. Performance features of the series includes low output noise, high ripple rejection ratio, low dropout and very fast turn-on times.

The XC6401 includes a reference voltage source, error amplifiers, driver transistors, current limiters and phase compensators internally. The XC6401's current limiters' foldback circuit also operates as a short protect for the output current limiter. The output voltage for each regulator is set independently by laser trimming. Voltages are selectable in 50mV steps within a range of 0.8V to 5.0V. The XC6401 series is also fully compatible with low ESR ceramic capacitors, reducing cost and improving output stability.

This high level of output stability is maintained even during frequent load fluctuations, due to the excellent transient response performance and high PSRR achieved across a broad range of frequencies. The EN function allows the output of each regulator to be turned off independently, resulting in greatly reduced power consumption. The XC6401 series is available in the SOT-26W or USP-6B, USP-6C 'chip-scale' package.

■APPLICATIONS

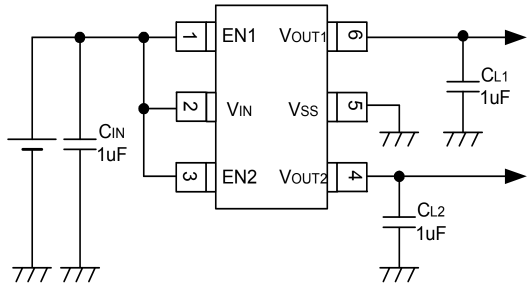
- ●Mobile Phones
- ●Cordless phones and radio communication equipment
- ●Portable games
- ●Cameras, Video recorders
- ●Portable Audio Equipment
- ●PDAs

■FEATURES

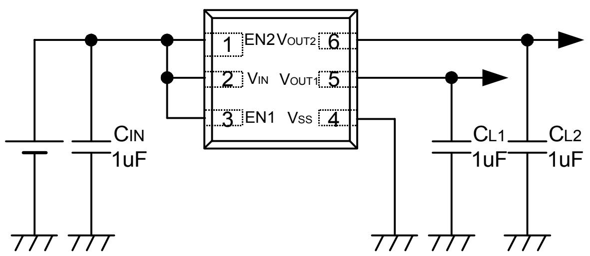
Maximum Output Current	: More than 150mA (300mA limit)
Dropout Voltage	: 100mV @100mA
Operating Voltage Range	: 1.5V ~ 6.0V
Output Voltage Range	: 0.8V~5.0V (50mV increments)
Highly Accurate	: ±2% (V_{OUT}>1.5V)
	: ±30mV (V_{OUT}≦1.5V)
Low Power Consumption	: 25 μ A (TYP.)
Standby Current	: Less than 0.1 μ A (TYP.)
High Ripple Rejection	: 70dB @1kHz
Operating Temperature Range	: -40℃ ~ +85℃
Low ESR Capacitor Compatible	: Ceramic capacitor
Low Output Noise	
Ultra Small Packages	: SOT-26W,USP-6B,USP-6C

■TYPICAL APPLICATION CIRCUITS

●SOT-26W

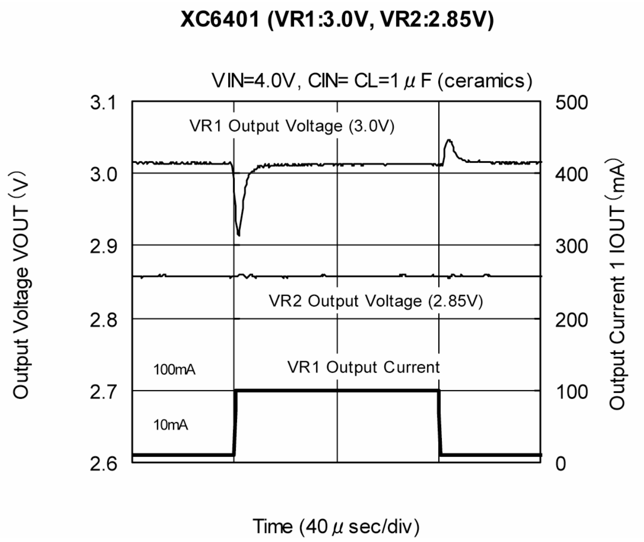


●USP-6

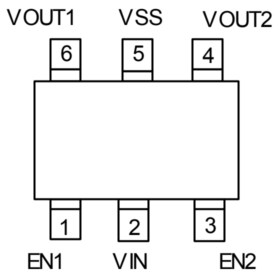


■TYPICAL PERFORMANCE CHARACTERISTICS

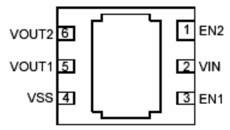
●Interactive Load Transient Response



■PIN CONFIGURATION



SOT-26W
(TOP VIEW)



USP-6B / 6C
(BOTTOM VIEW)

*The dissipation pad for the USP-6B/C packages should be solder-plated in recommended mount pattern and metal masking so as to enhance mounting strength and heat release.
If the pad needs to be connected to other pins, it should be connected to the VSS pin.

■PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTION
SOT-26W	USP-6B/C		
1	3	EN1	ON/OFF Control 1
2	2	V_{IN}	Power Input
3	1	EN2	ON/OFF Control 2
4	6	V_{OUT2}	Output 2
5	4	V_{SS}	Ground
6	5	V_{OUT1}	Output 1

■PRODUCT CLASSIFICATION

●Selection Guide

The following options for the Regulator 1, 2, the EN pin logic, internal pull-up / down are available.

●Ordering Information

XC6401①②③④⑤⑥

DESIGNATOR	DESCRIPTION	SYMBOL	DESCRIPTION
①	Regulator1, EN type	E	: High Active with pull-down resistor
		F	: High Active with no pull-down resistor
		G	: Low Active with pull-up resistor
		H	: Low Active with no pull-up resistor
②	Regulator2, EN type	E	: High Active with pull-down resistor
		F	: High Active with no pull-down resistor
		G	: Low Active with pull-up resistor
		H	: Low Active with no pull-up resistor
③④	Output Voltage	01~	: Internally set sequential number relating output voltage of each regulators Regulator 1 Output Voltage Range: 0.8 ~ 5.0 V (50mV increments) Regulator 2 Output Voltage Range: 0.8 ~ 5.0 V (50mV increments)
⑤	Packaging Types	M	: SOT-26W
		D	: USP-6B
		E	: USP-6C
⑥	Device Orientation	R	: Embossed tape, standard feed
		L	: Embossed tape, reverse feed

■ABSOLUTE MAXIMUM RATINGS

Ta = 25℃

PARAMETER		SYMBOL	RATINGS	UNITS
Input Voltage		V_{IN}	6.5	V
Output Current		I_{OUT1} + I_{OUT2}	700	mA
Output Voltage		V_{OUT}	V_{SS} -0.3 ~ V_{IN} +0.3	V
EN Pin Voltage		V_{EN}	V_{SS} -0.3 ~ 6.5	V
Power Dissipation	SOT-26W	Pd	250	mW
	USP-6B		100	
	USP-6C		100	
Operating Temperature Range		Topr	-40 ~ +85	℃
Storage Temperature Range		Tstg	-55 ~ +125	℃

* Sum of I_{OUT1} and I_{OUT2}.

** Pd=(V_{IN}-V_{OUT1})xI_{OUT1}+(V_{IN}-V_{OUT2})xI_{OUT2}

■ELECTRICAL CHARACTERISTICS

XC6401FFxx

Regulator 1, Regulator 2

Ta=25℃

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNITS	CIRCUIT
Output Voltage (*3)	$V_{OUT(E)}$	V_{IN}=$V_{OUT(T)}$ + 1.0V I_{OUT}=30mA	0.98	$V_{OUT(T)}$	1.02	V	1
Maximum Output Current	I_{OUTMAX}	V_{IN}=$V_{OUT(T)}$ + 1.0V	150	-	-	mA	1
Load Regulation	ΔV_{OUT}	1mA≦I_{OUT}≦100mA	-	15	60	mV	1
Dropout Voltage	Vdif1	I_{OUT}=30mA	E-1			mV	1
	Vdif2	I_{OUT}=100mA	E-2			mV	
Supply Current	I_{SS}	V_{IN}=V_{EN}=$V_{OUT(T)}$ + 1.0V, I_{OUT}=0mA	-	25	45	μA	2
Standby Current	I_{STB}	V_{IN}=$V_{OUT(T)}$ + 1.0V, V_{EN}=V_{SS}	-	0.01	0.10	μA	3
Line Regulation (*7)	$\frac{\Delta V_{OUT}}{\Delta V_{IN} \cdot V_{OUT}}$	$V_{OUT(T)}$+1.0V≦V_{IN}≦6.0V V_{EN}=V_{IN}, I_{OUT}=30mA	-	0.01	0.20	% / V	1
Input Voltage	V_{IN}		1.5	-	6.0	V	-
Output Voltage Temperature Characteristics	$\frac{\Delta V_{OUT}}{\Delta Topr \cdot V_{OUT}}$	I_{OUT}=30mA -40℃≦Topr≦85℃	-	±100	-	ppm/℃	1
Ripple Rejection Rate(*8)	PSRR	V_{IN}=[$V_{OUT(T)}$+1.0]V_{DC}+0.5Vp-pAC I_{OUT}=30mA, f=1kHz	-	70	-	dB	5
Current Limiter	I_{lim}	V_{IN}=$V_{OUT(T)}$ + 1.0V, V_{EN}=V_{IN}	-	300	-	mA	1
Short-Circuit Current	Ishort	V_{IN}=$V_{OUT(T)}$ + 1.0V, V_{EN}=V_{IN}	-	30	-	mA	1
EN "High" Voltage	V_{ENH}		1.30	-	6.0	V	4
EN "Low" Voltage	V_{ENL}		-	-	0.25	V	4
EN "High" Current	I_{ENH}	V_{IN}=V_{EN}=$V_{OUT(T)}$ + 1.0V	-0.10	-	0.10	μA	4
EN "Low" Current	I_{ENL}	V_{IN}= $V_{OUT(T)}$ + 1.0V, V_{EN}=V_{SS}	-0.10	-	0.10	μA	4

NOTE *1: $V_{OUT(T)}$=Specified output voltage

*2: $V_{OUT(E)}$=Effective output voltage
(I.e. the output voltage when "$V_{OUT(T)}$＋1.0V" is provided at the V_{IN} pin while maintaining a certain I_{OUT} value).

*3: If $V_{OUT(T)}$≦1.45V, MIN $V_{OUT(T)}$ - 30mV, MAX $V_{OUT(T)}$ + 30mV

*4: Vdif={V_{IN1}(*6)-V_{OUT1}(*5)}

*5: V_{OUT1}=A voltage equal to 98% of the output voltage whenever an amply stabilized I_{OUT} {$V_{OUT(T)}$+1.0V} is input.

*6: V_{IN1}=the input voltage when V_{OUT1} appears as input voltage is gradually decreased.

*7: When $V_{OUT(T)}$≧4.5V, 5.5V≦V_{IN}≦6.0V

*8: When $V_{OUT(T)}$≧4.8V, V_{IN}=5.75VDC+0.5Vp-pAC

*9: Unless otherwise stated, V_{IN}=$V_{OUT(T)}$+1.0V

■ELECTRICAL CHARACTERISTICS (Continued)

●Dropout Voltage

SETTING OUTPUT VOLTAGE (V)	DETECT VOLTAGE (V)		E-1 DROPOUT VOLTAGE 1 (mV)		E-2 DROPOUT VOLTAGE 2 (mV)	
	VOUT		Vdif 1		Vdif 2	
VOUT(T)	MIN.	MAX.	TYP.	MAX.	TYP.	MAX.
0.80	0.770	0.830	300	700	400	800
0.85	0.820	0.880				
0.90	0.870	0.930	200	600	350	700
0.95	0.920	0.980				
1.00	0.970	1.030	100	500	270	600
1.05	1.020	1.080				
1.10	1.070	1.130	80	400	240	500
1.15	1.120	1.180				
1.20	1.170	1.230	65	300	200	400
1.25	1.220	1.280				
1.30	1.270	1.330	60	200	180	300
1.35	1.320	1.380				
1.40	1.370	1.430	55	100	165	250
1.45	1.420	1.480				
1.50	1.470	1.530	50	75	150	200
1.55	1.519	1.581				
1.60	1.568	1.632				
1.65	1.617	1.683				
1.70	1.666	1.734				
1.75	1.715	1.785				
1.80	1.764	1.836	45	65	140	180
1.85	1.813	1.887				
1.90	1.862	1.938				
1.95	1.911	1.989				
2.00	1.960	2.040	40	60	120	170
2.05	2.009	2.091				
2.10	2.058	2.142				
2.15	2.107	2.193				
2.20	2.156	2.244				
2.25	2.205	2.295				
2.30	2.254	2.346				
2.35	2.303	2.397				
2.40	2.352	2.448				
2.45	2.401	2.499				
2.50	2.450	2.550	35	55	110	160
2.55	2.499	2.601				
2.60	2.548	2.652				
2.65	2.597	2.703				
2.70	2.646	2.754				
2.75	2.695	2.805				
2.80	2.744	2.856				
2.85	2.793	2.907				
2.90	2.842	2.958				
2.95	2.891	3.009				

■DROPOUT VOLTAGE CHART (Continued)

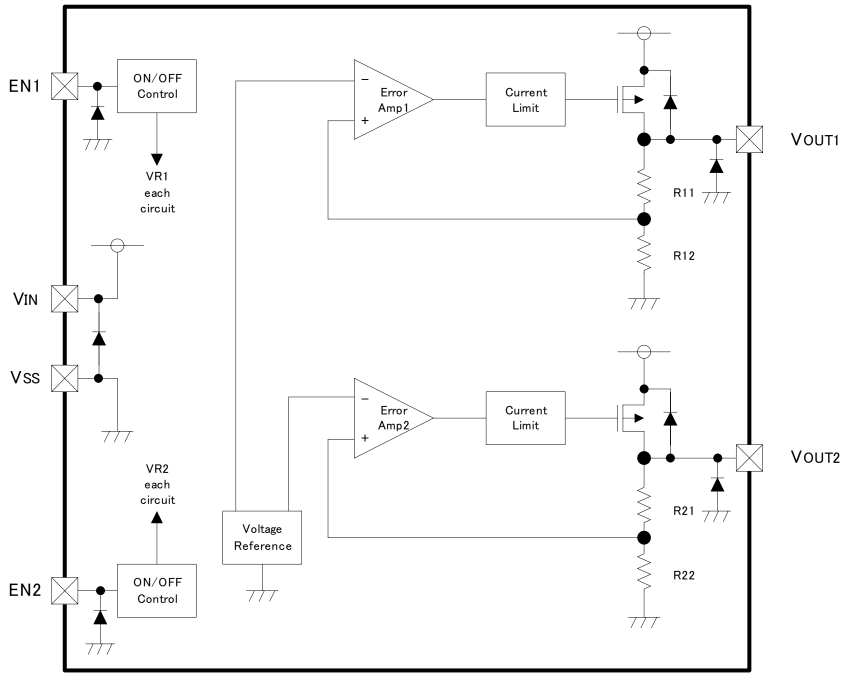
●Dropout Voltage (Continued)

SETTING OUTPUT VOLTAGE	DETECT VOLTAGE		E-1 DROPOUT VOLTAGE 1		E-2 DROPOUT VOLTAGE 2	
	(V)		(mV)		(mV)	
(V)	VOUT		Vdif 1		Vdif 2	
VOUT(T)	MIN.	MAX.	TYP.	MAX.	TYP.	MAX.
3.00	2.940	3.060	30	45	100	150
3.05	2.989	3.111				
3.10	3.038	3.162				
3.15	3.087	3.213				
3.20	3.136	3.264				
3.25	3.185	3.315				
3.30	3.234	3.366				
3.35	3.283	3.417				
3.40	3.332	3.468				
3.45	3.381	3.519				
3.50	3.430	3.570				
3.55	3.479	3.621				
3.60	3.528	3.672				
3.65	3.577	3.723				
3.70	3.626	3.774				
3.75	3.675	3.825				
3.80	3.724	3.876				
3.85	3.773	3.927				
3.90	3.822	3.978				
3.95	3.871	4.029				
4.00	3.920	4.080				
4.05	3.969	4.131				
4.10	4.018	4.182				
4.15	4.067	4.233				
4.20	4.116	4.284				
4.25	4.165	4.335				
4.30	4.214	4.386				
4.35	4.263	4.437				
4.40	4.312	4.488				
4.45	4.361	4.539				
4.50	4.410	4.590				
4.55	4.459	4.641				
4.60	4.508	4.692				
4.65	4.557	4.743				
4.70	4.606	4.794				
4.75	4.655	4.845				
4.80	4.704	4.896				
4.85	4.753	4.947				
4.90	4.802	4.998				
4.95	4.851	5.049				
5.00	4.900	5.100				

■OPERATIONAL EXPLANATION

<Output Voltage Control>

The voltage divided by resistors R1 & R2 is compared with the internal reference voltage by the error amplifier. The P-channel MOSFETs, which are connected to the V_{OUT1} and V_{OUT2} pins, are then driven by the subsequent output signal. The output voltages at the V_{OUT1} and V_{OUT2} pins are controlled and stabilized by a system of negative feedback. The current limit circuit and short protect circuit operate in relation to the level of output current. Further, the IC's internal circuitry can be shutdown via the EN pin's signal.



<Low ESR Capacitors>

With the XC6401 series, a stable output voltage is achievable even if used with low ESR capacitors as a phase compensation circuit is built-in. In order to ensure the effectiveness of the phase compensation, we suggest that output capacitors (CL1, CL2) is connected as close as possible to the output pins (V_{OUT1} and V_{OUT2}) and the V_{SS} pin. Please use an output capacitor with a capacitance value of at least 1 μF. Also, please connect an input capacitor (C_{IN}) of 1 μF between the V_{IN} pin and the V_{SS} pin in order to ensure a stable power input.

<Current Limiter, Short-Circuit Protection>

The XC6401 series includes a combination of a fixed current limiter circuit & a foldback circuit which aid the operations of the current limiter and circuit protection. When the load current reaches the current limit level, the fixed current limiter circuit operates and output voltage drops. As a result of this drop in output voltage, the foldback circuit operates, output voltage drops further and output current decreases. When the output pin is shorted, a current of about 30mA flows.

<EN Pins>

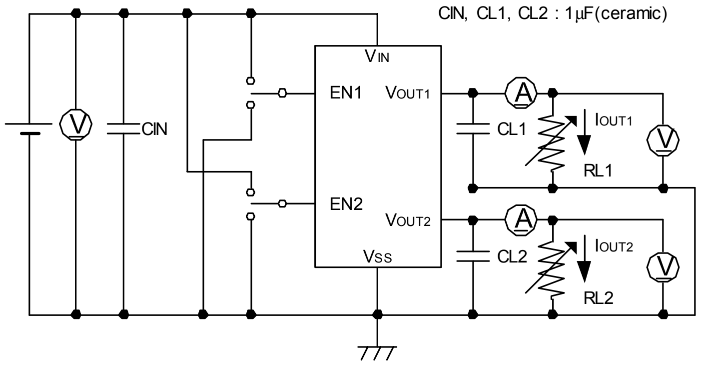
The IC's internal circuitry can be shutdown via the signal from the EN1 and EN2 pins with the XC6401 series. In shutdown mode, output at the V_{OUT1} and V_{OUT2} pins will be pulled down to the V_{SS} level via R11 & R12 and R21 & R22. The operational logic of the IC's EN1 and EN2 pins are selectable (please refer to the selection guide). Note that as the standard XC6401FF type's regulator 1 and 2 are both ' High Active/No Pull Down', operations will become unstable with the EN1 or EN2 pins open. Although the EN1 and EN2 pins are equal to an inverter input with CMOS hysteresis, with either the pull-up or pull-down options, the EN1 and EN2 pins input current will increase when the IC is in operation. We suggest that you use this IC with either a V_{IN} voltage or a V_{SS} voltage input at the EN1 and EN2 pins. If this IC is used with the correct specifications for the EN1 and EN2 pins, the operational logic is fixed and the IC will operate normally. However, supply current may increase as a result of through current in the IC's internal circuitry.

■NOTES ON USE

1. Please use this IC within the stated absolute maximum ratings.
   The IC is liable to malfunction should the ratings be exceeded.
2. Where wiring impedance is high, operations may become unstable due to noise and/or phase lag depending on output current. Please keep the resistance low between V_{IN} and V_{SS} wiring in particular.
3. Please wire the input capacitor (C_{IN}) and the output capacitors (C_{L1}, C_{L2}) as close to the IC as possible.

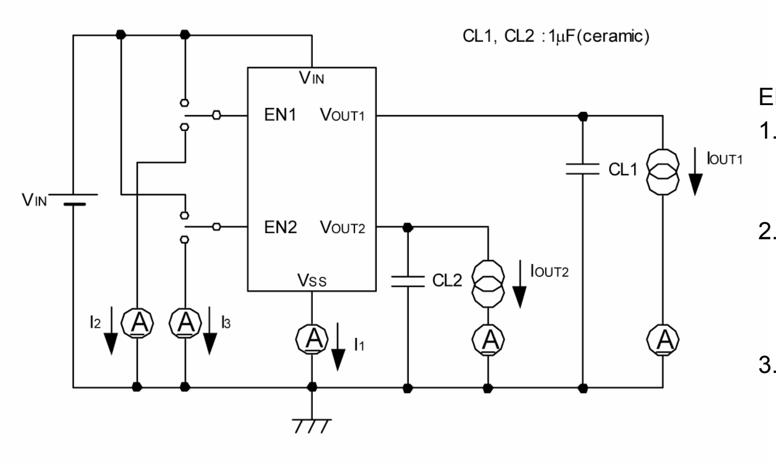
■TEST CIRCUITS

Circuit ①



EN1/EN2 :
High Active = EN=V_{IN}
Low Active = EN=V_{SS}

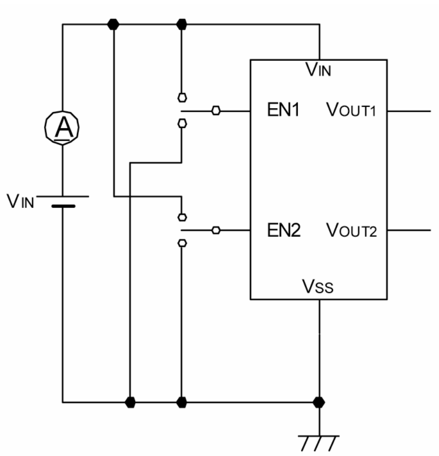
Circuit ②



EN1/EN2 :

1. High Active with pull-down resistor built-in
   VR1 Supply Current I_{SS1}=I1 (Note:EN1=ON, EN2=OFF)
   VR2 Supply Current I_{SS2}=I1 (Note:EN1=OFF, EN2=ON)
2. High Active with no pull-down resistor built-in
   VR1 Supply Active Current I_{SS1}=I1
   (Note:EN1=ON, EN2=OFF)
   VR2 Supply Current I_{SS2}=I1 (Note:EN1=OFF, EN2=ON)
3. Low Active with pull-up resistor built-in
   VR1 Supply Current I_{SS1}=I1+I2
   (Note:EN1=ON, EN2=OFF)
   VR2 Supply Current I_{SS2}=I1+I3
   (Note:EN1=OFF, EN2=ON)
4. Low Active with no pull-up resistor built-in
   VR1 Supply Current I_{SS1}=I1 (Note:EN1=ON, EN2=OFF)
   VR2 Supply Current I_{SS2}=I1 (Note:EN1=OFF, EN2=ON)

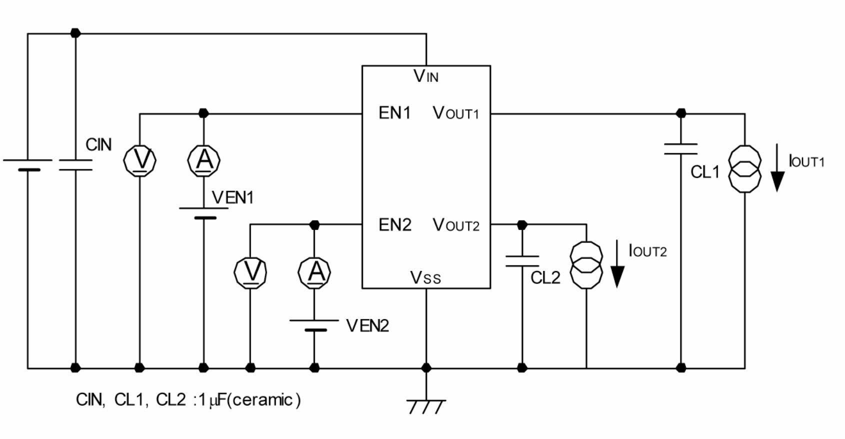
Circuit ③



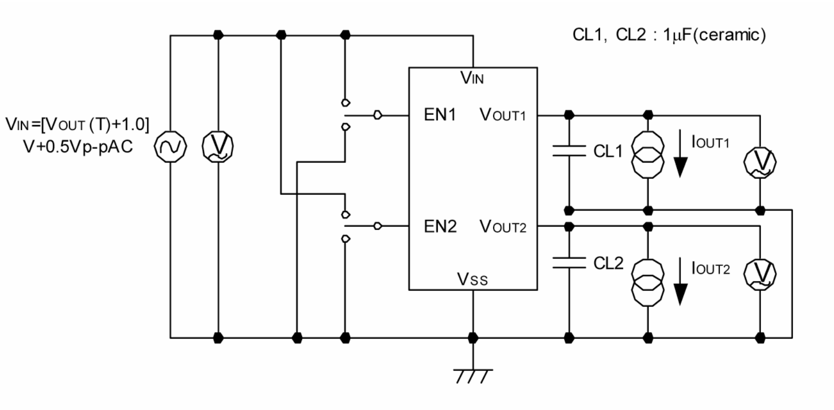
EN1/EN2:
High Active = EN= V_{SS}
Low Active = EN= V_{IN}

■TEST CIRCUITS (Continued)

Circuit ④



Circuit ⑤

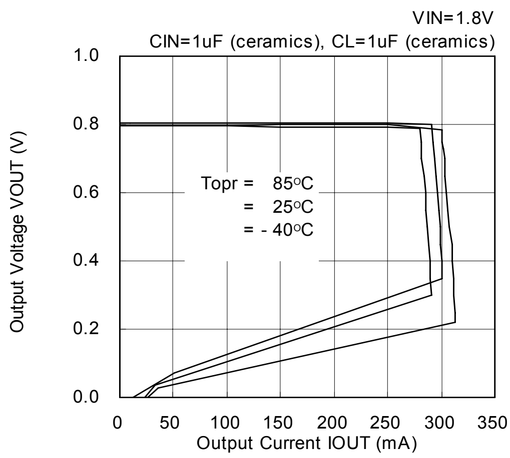


EN1/EN2 :
High Active = EN=VIN
Low Active = EN=VSS

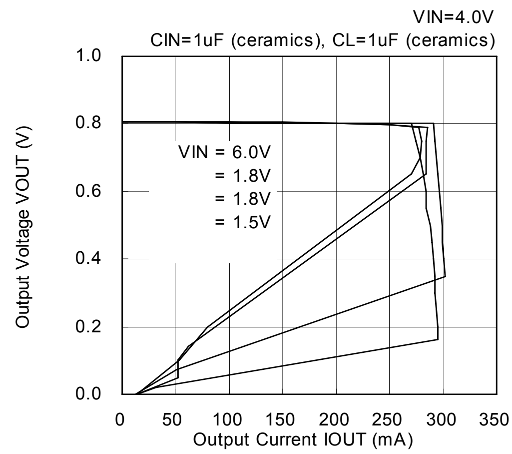
■TYPICAL PERFORMANCE CHARACTERISTICS

(1) Output Voltage vs. Output Current

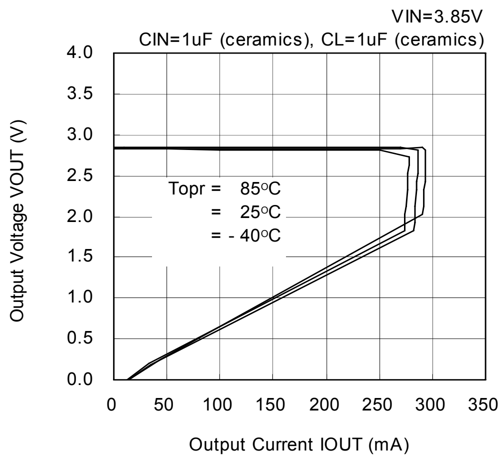
XC6401 (0.8V)



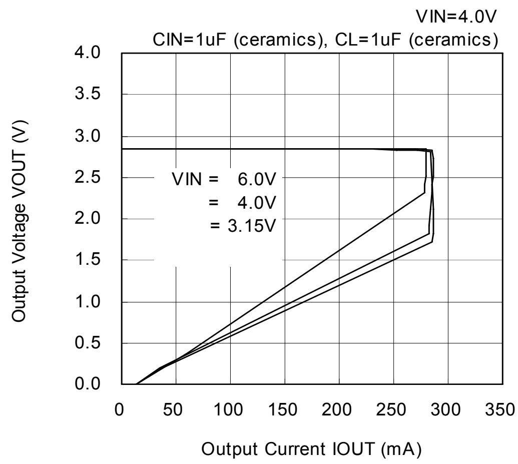
XC6401(0.8V)



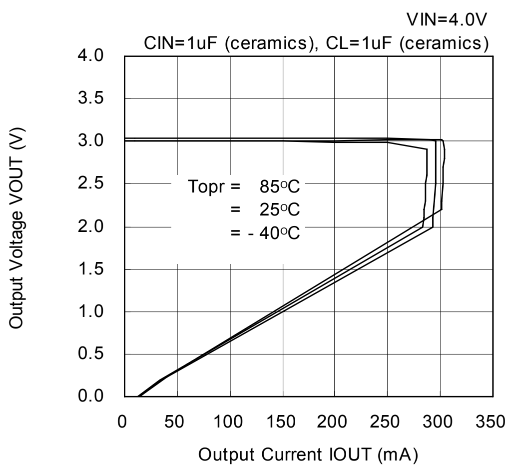
XC6401(2.85V)



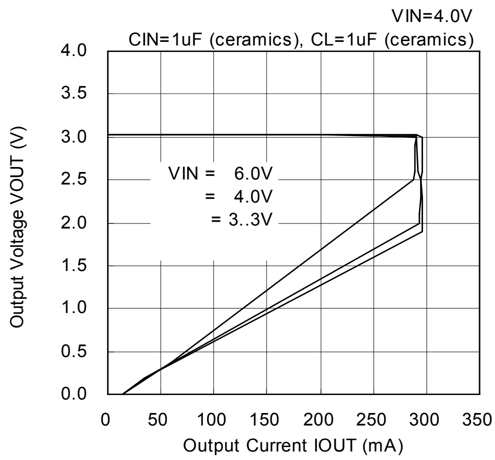
XC6401(2.85V)



XC6401(3.0V)

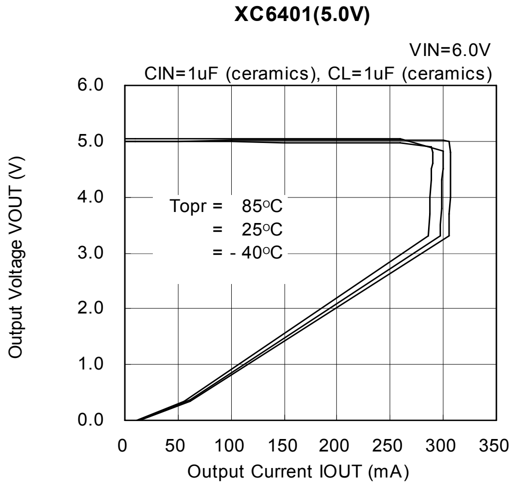


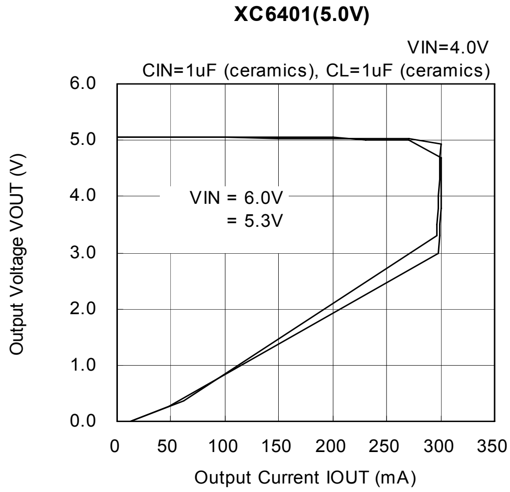
XC6401(3.0V)



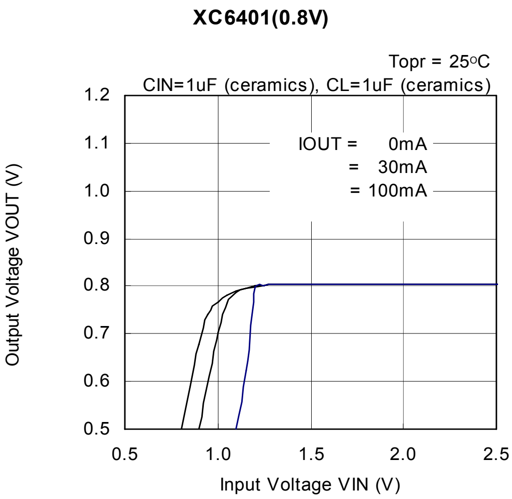
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

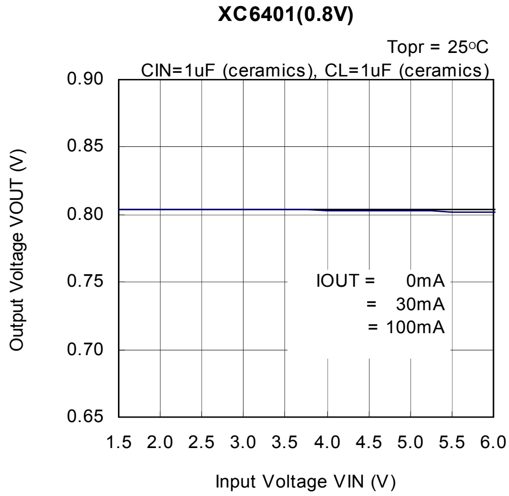
(1) Output Voltage vs. Output Current (Continued)

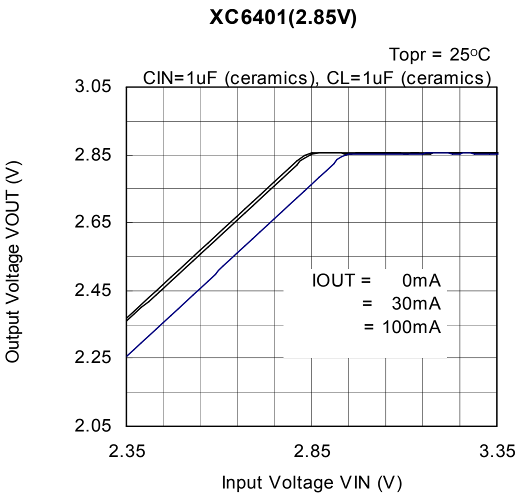


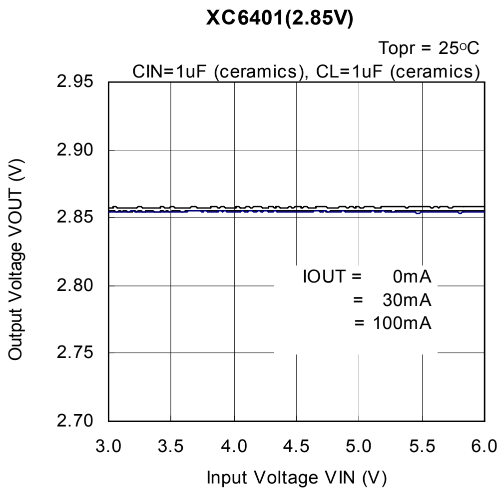


(2) Output Voltage vs. Input Voltage



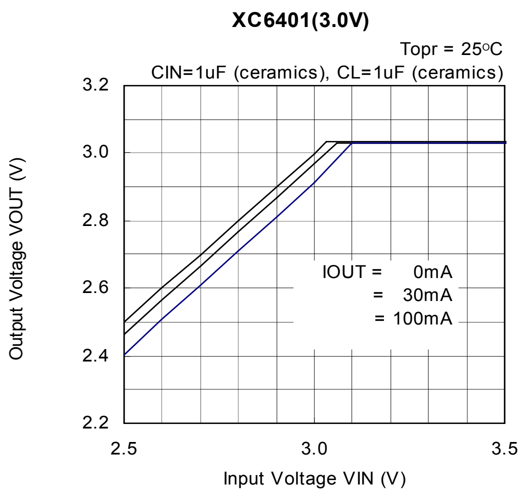


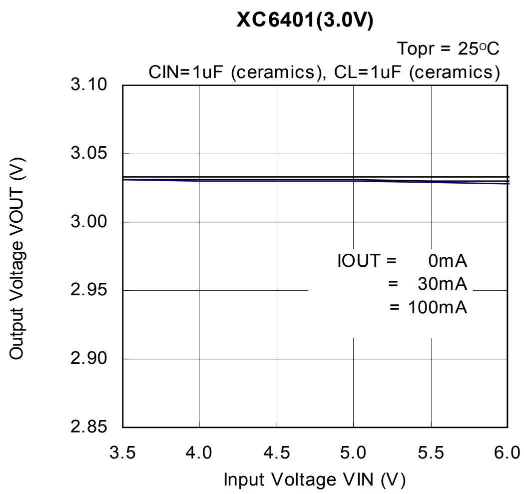


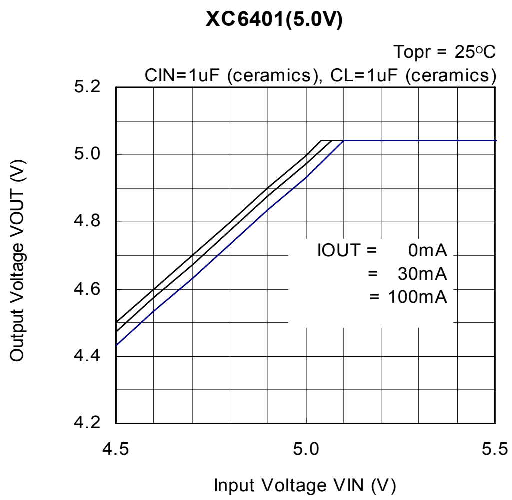


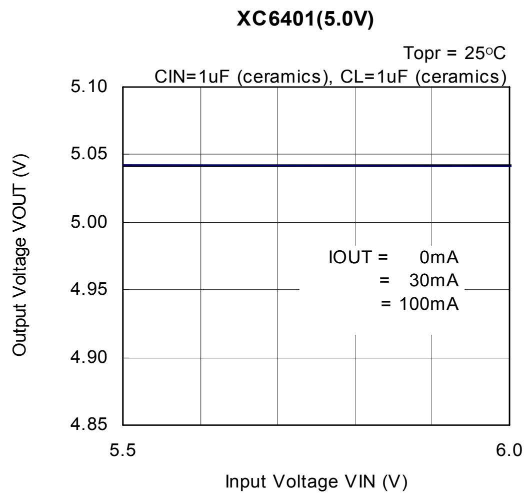
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(2) Output Voltage vs. Input Voltage (Continued)

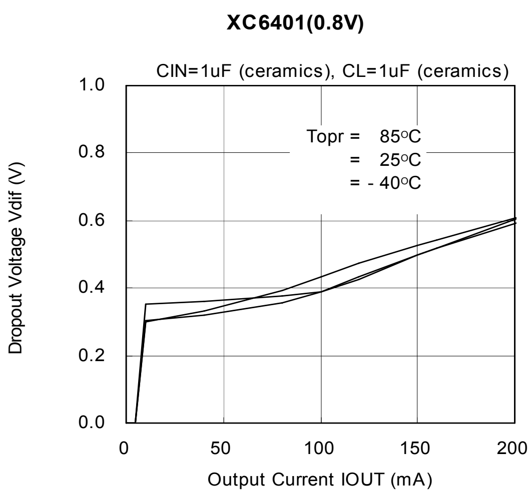


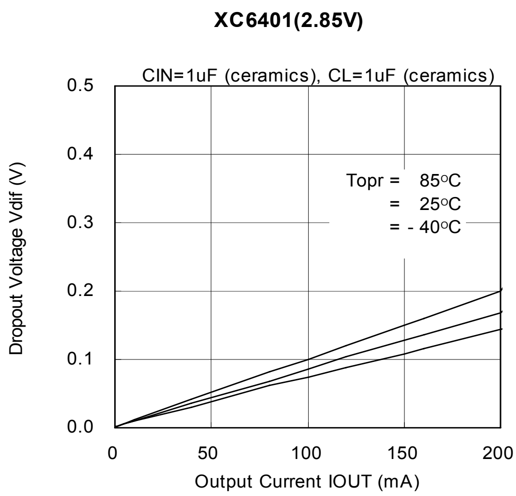






(3) Dropout Voltage vs. Output Current

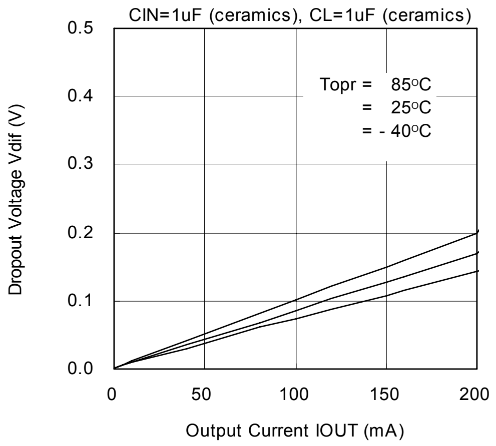




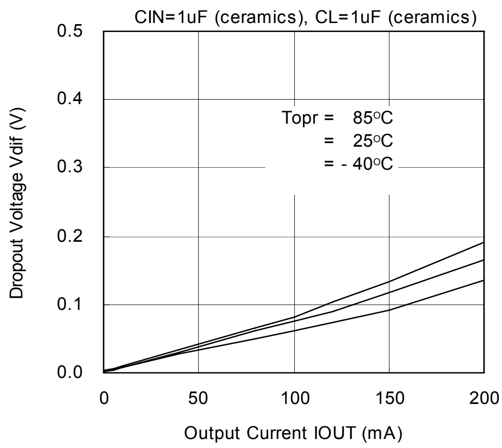
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(3) Dropout Voltage vs. Output Current (Continued)

XC6401(3.0V)

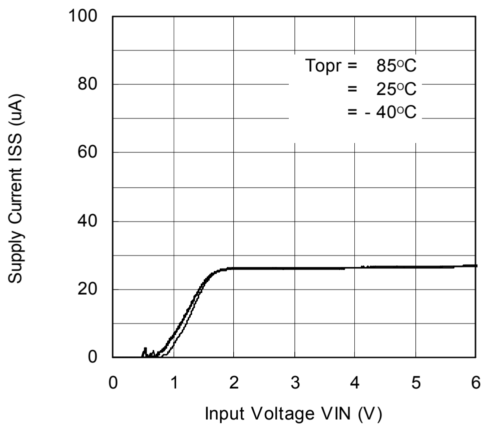


XC6401(5.0V)

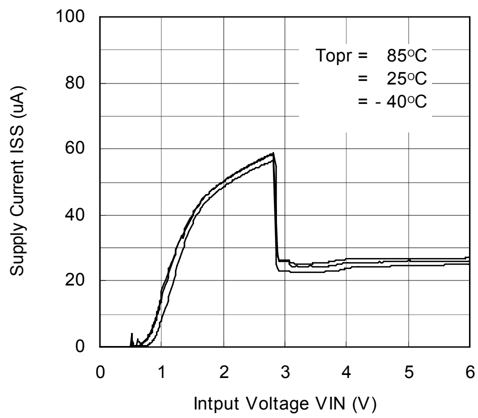


(4) Supply Current vs. Input Voltage

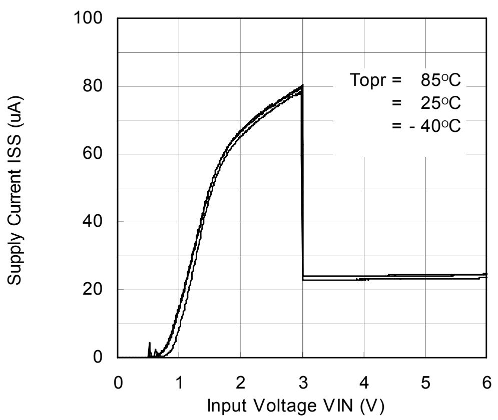
XC6401(0.8V)



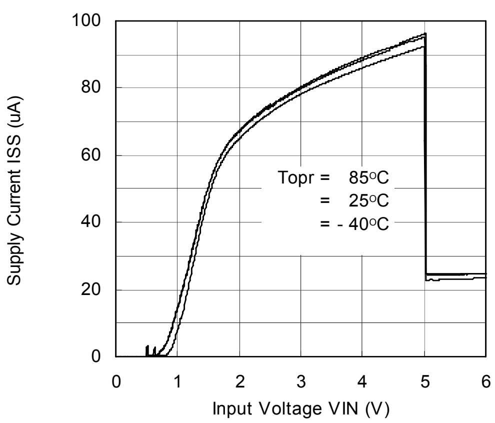
XC6401(2.85V)



XC6401(3.0V)

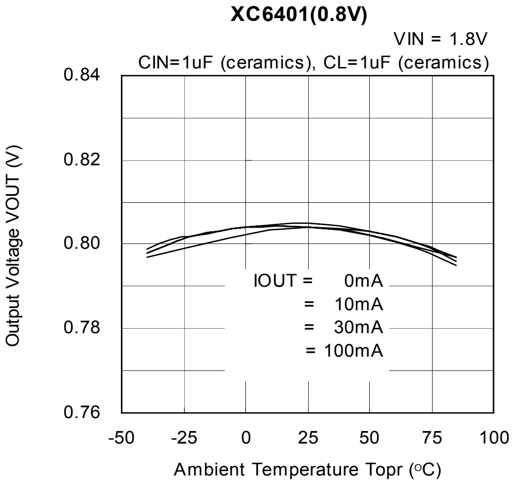


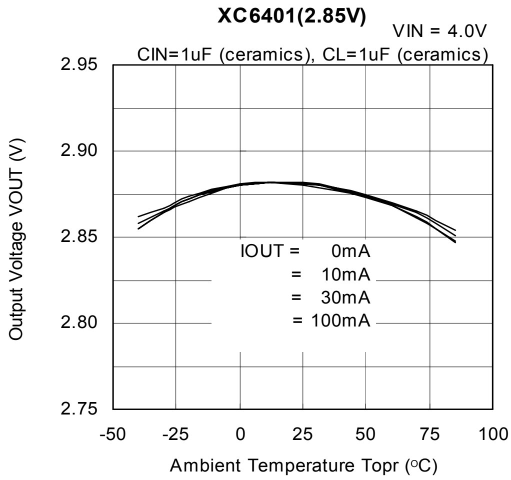
XC6401(5.0V)

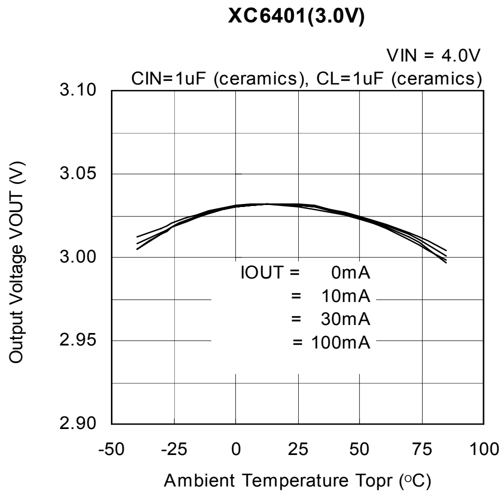


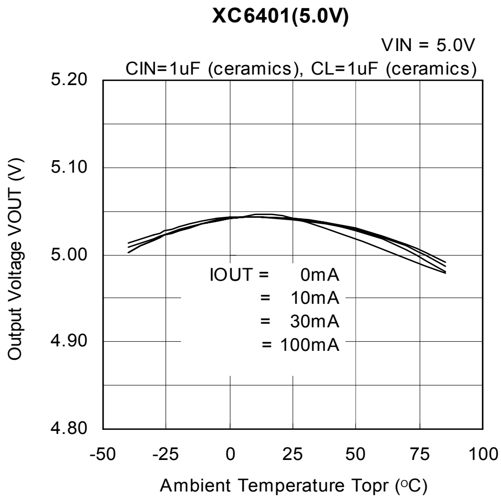
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(5) Output Voltage vs. Ambient Temperature

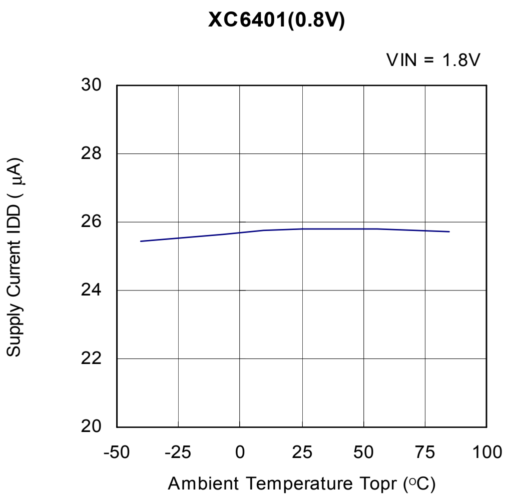


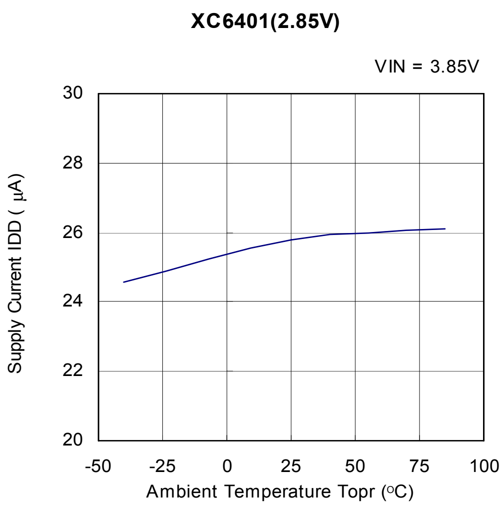






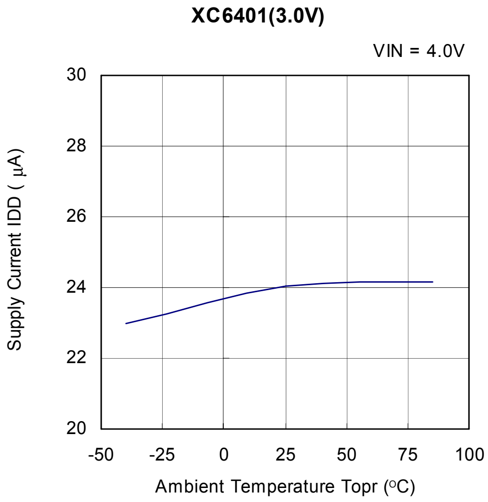
(6) Supply Current vs. Ambient Temperature

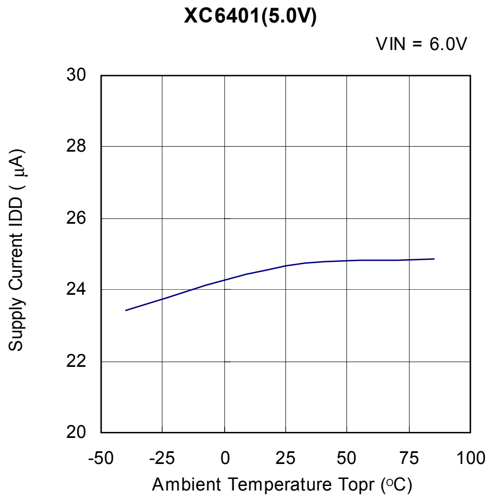




■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

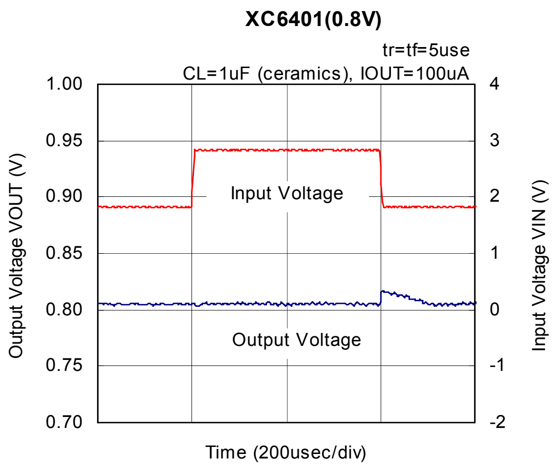
(6) Supply Current vs. Ambient Temperature (Continued)

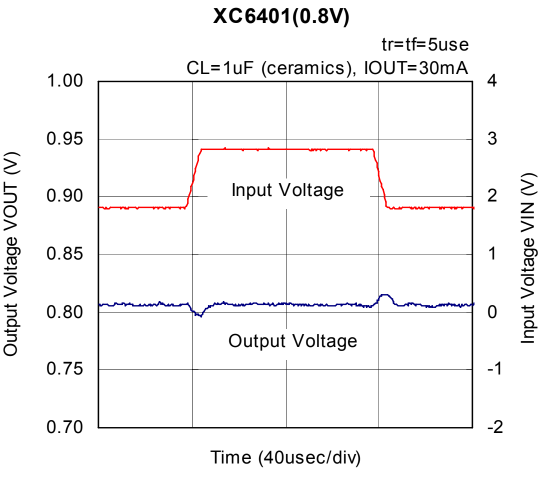


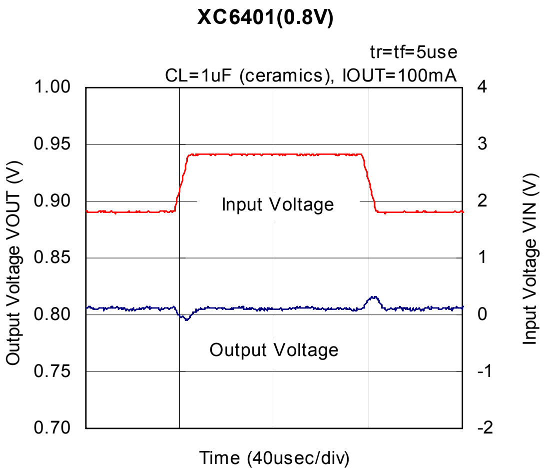


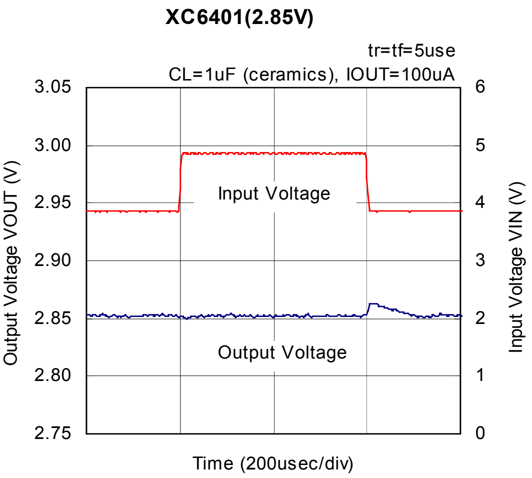
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

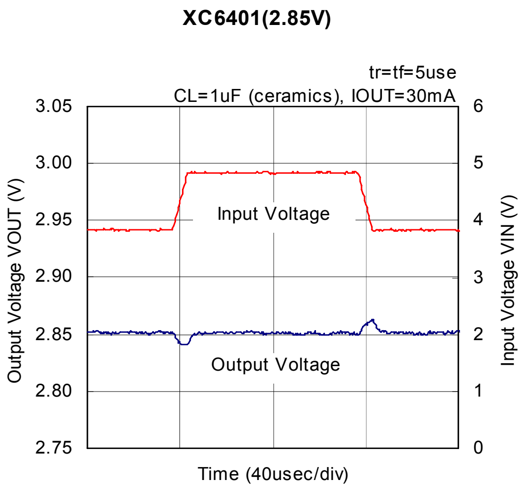
(7) Input Transient Response

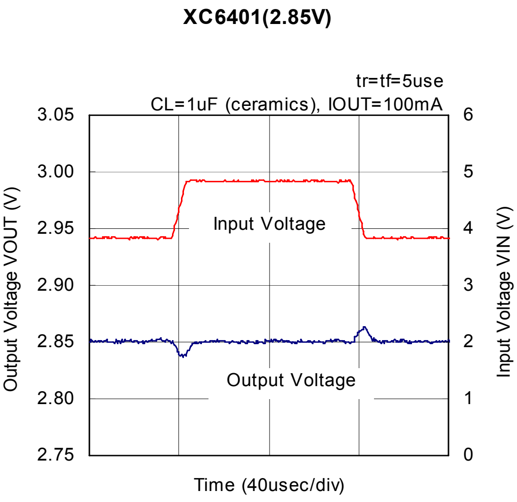






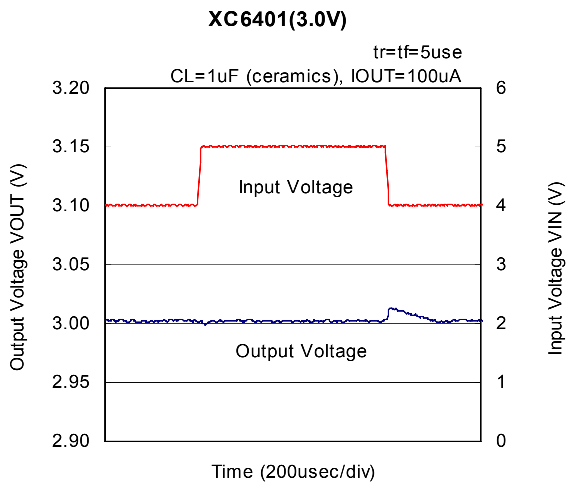


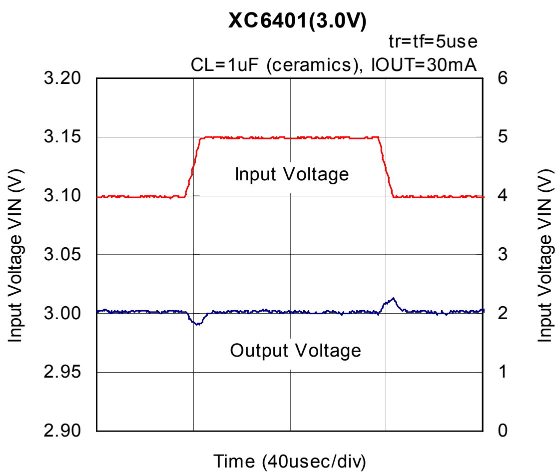


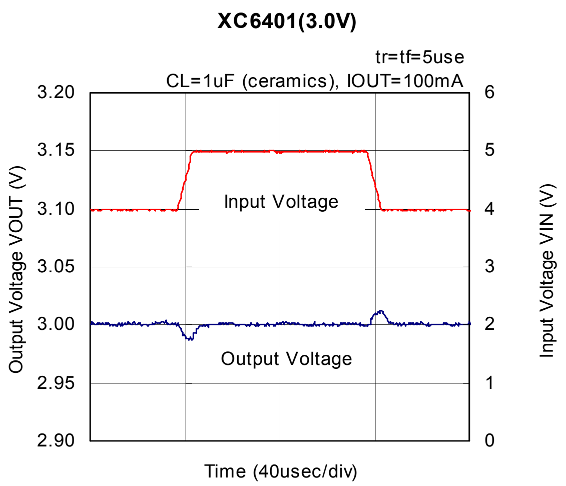


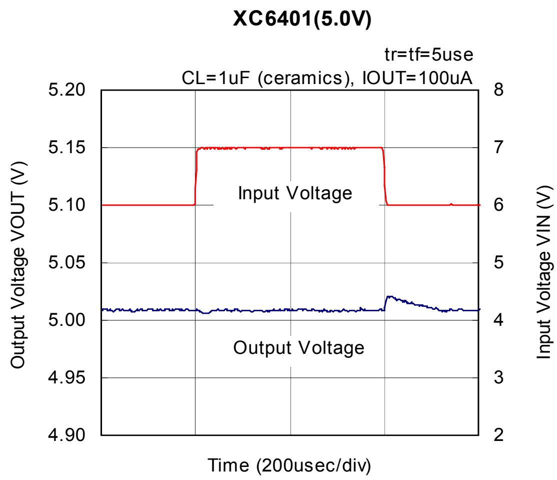
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

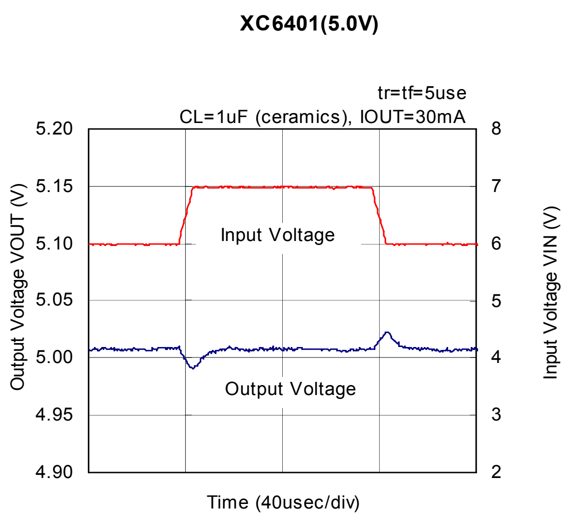
(7) Input Transient Response (Continued)

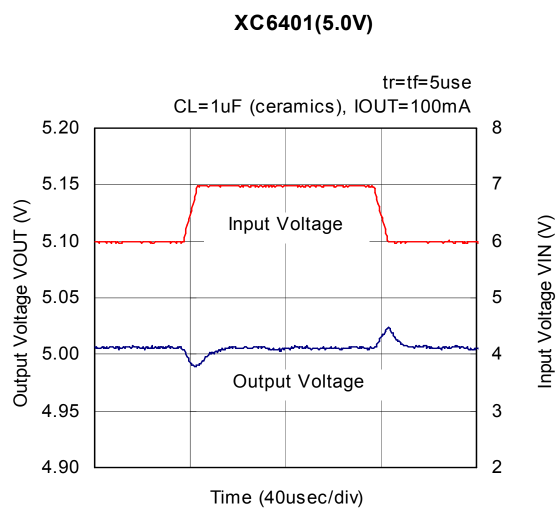






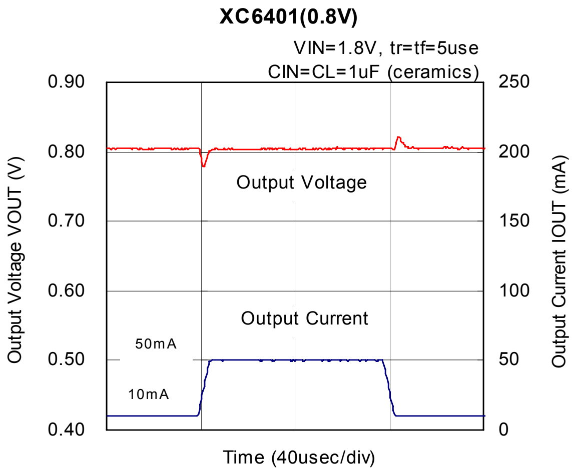


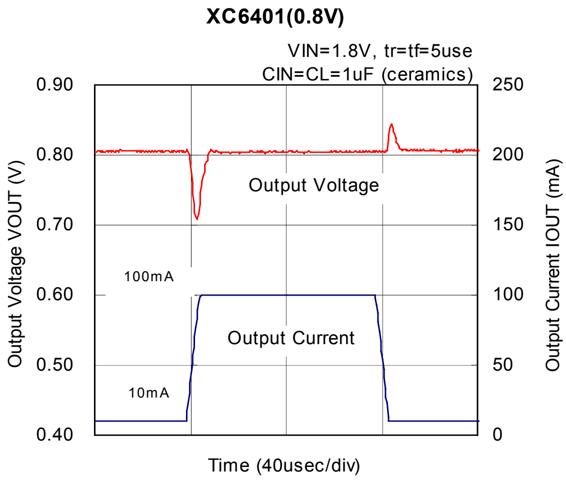


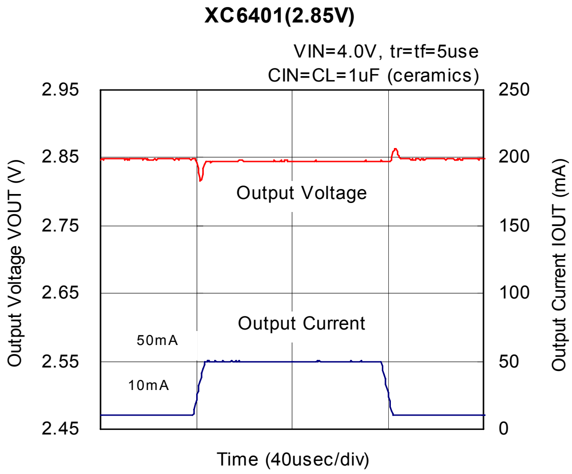


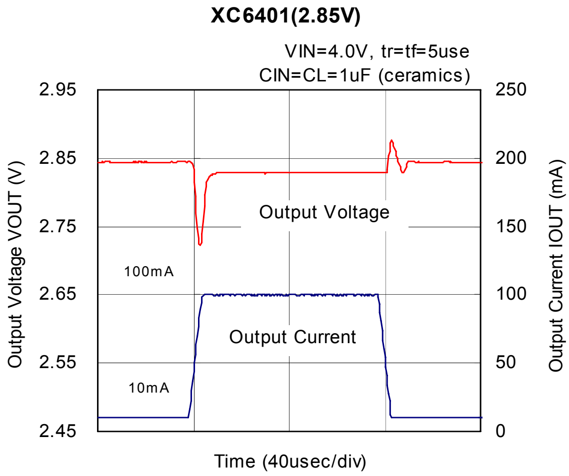
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

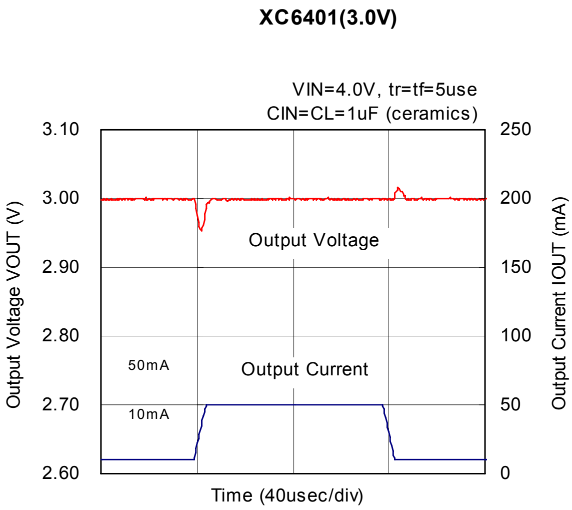
(8) Load Transient Response

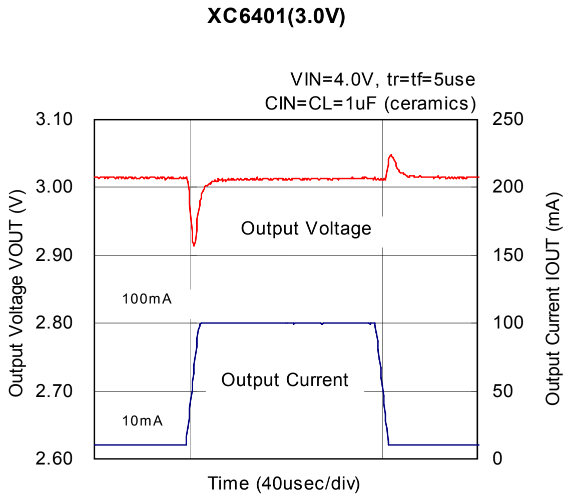






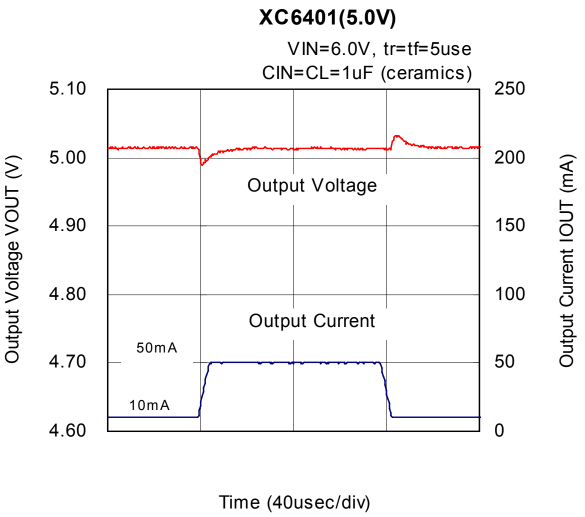


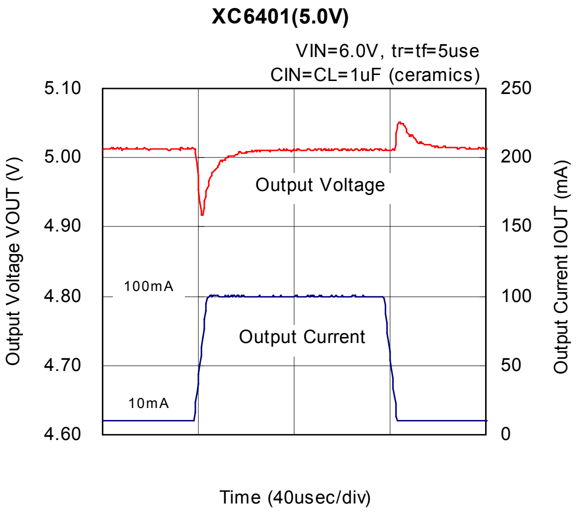




■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

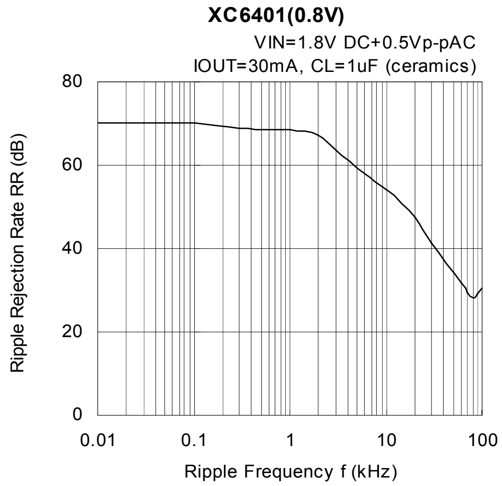
(8) Load Transient Response (Continued)

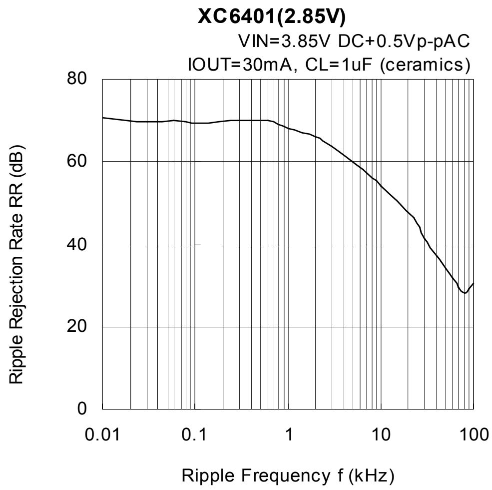


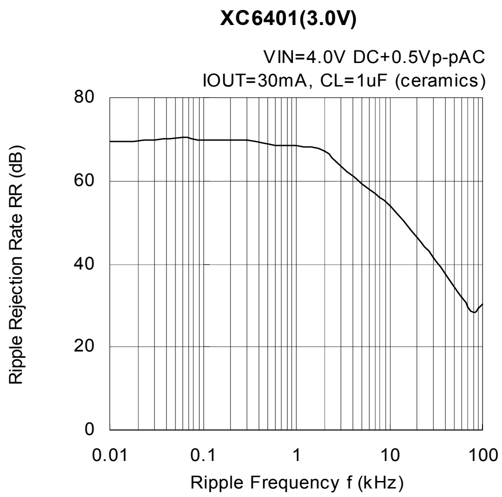


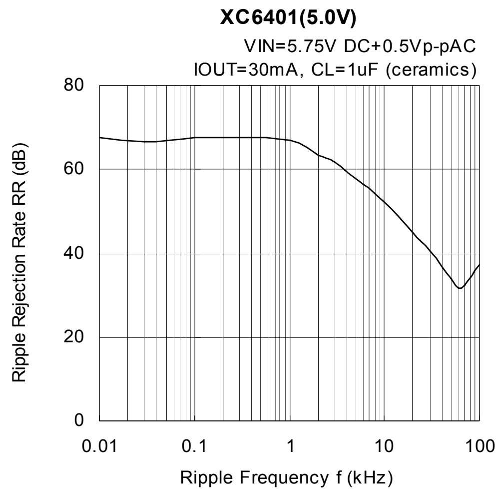
■TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(9) Ripple Rejection Rate

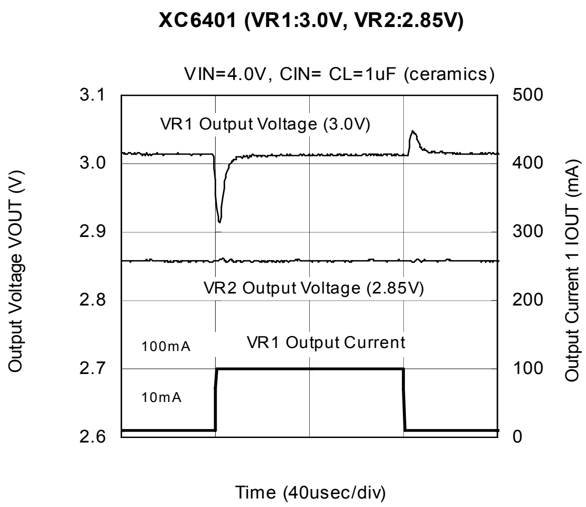






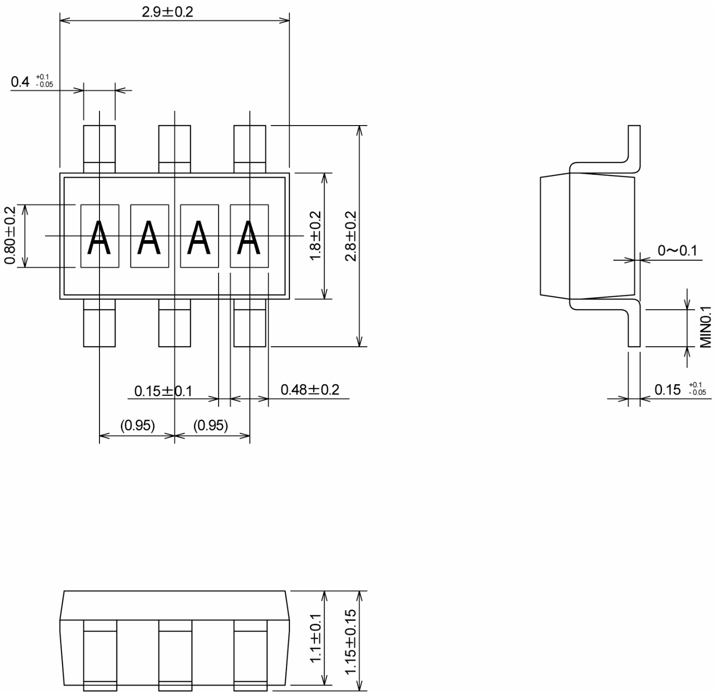


(10) Cross Talk

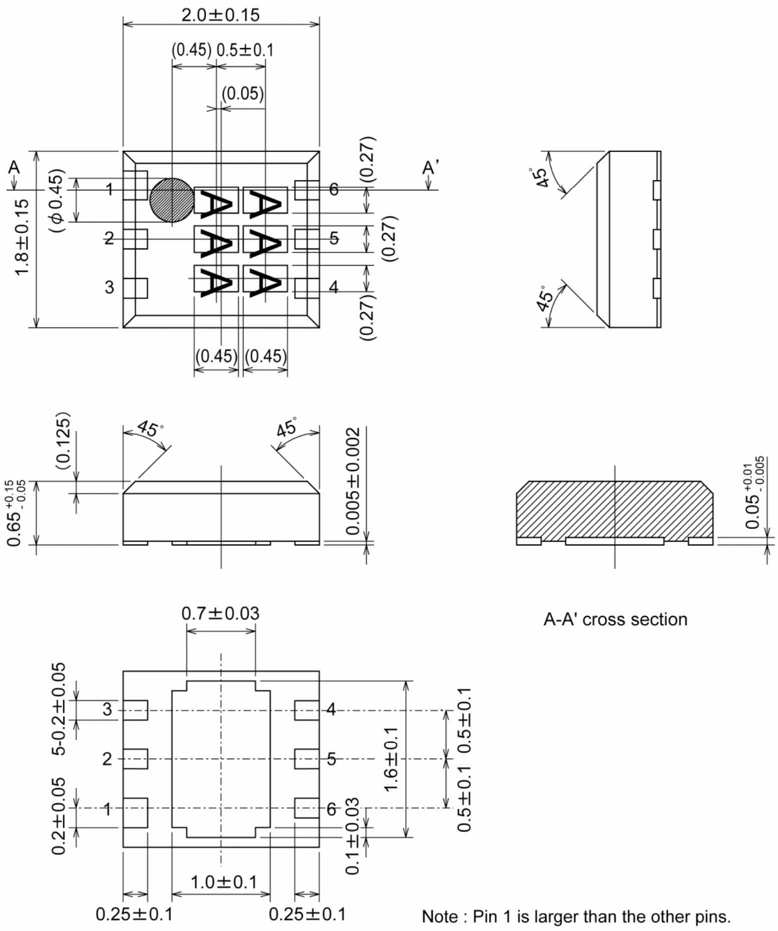


■PACKAGING INFORMATION

●SOT-26W

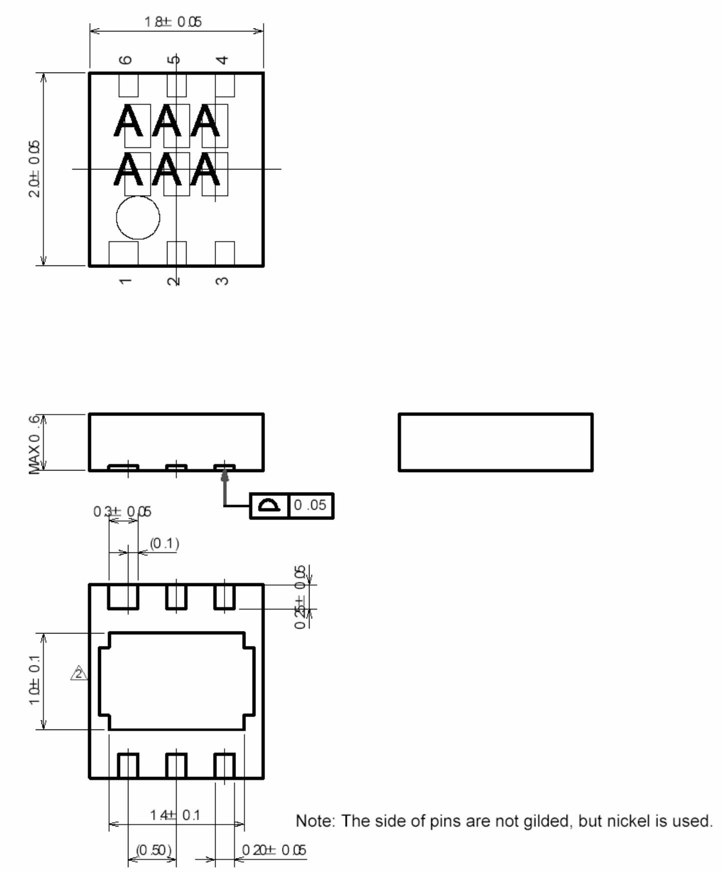


●USP-6B



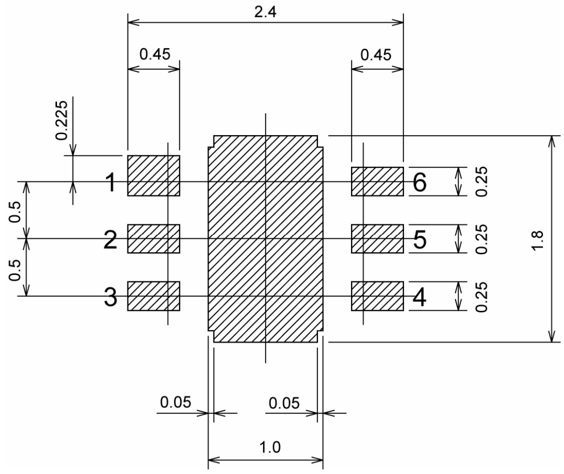
■PACKAGING INFORMATION (Continued)

●USP-6C

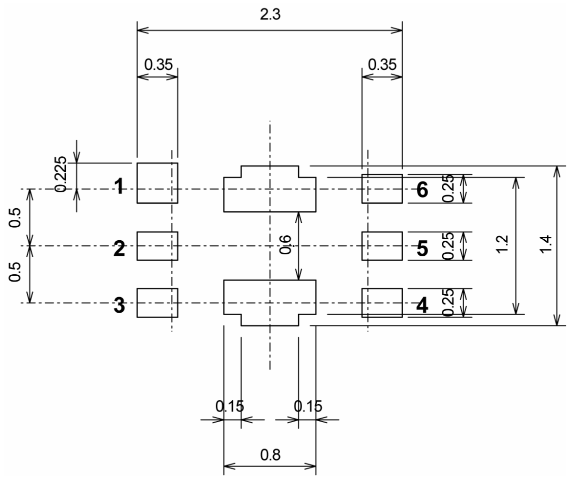


■PACKAGING INFORMATION (Continued)

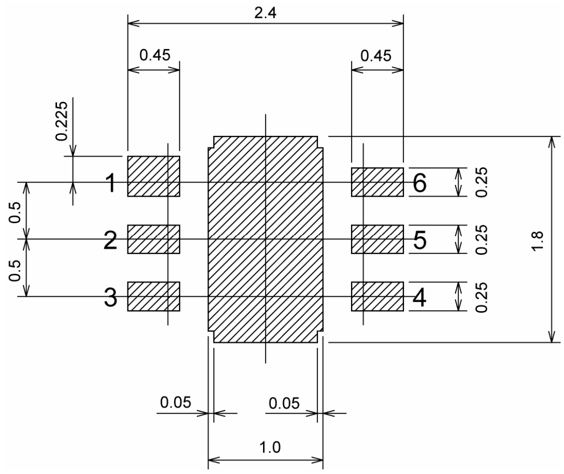
●USP-6B Recommended Pattern Layout



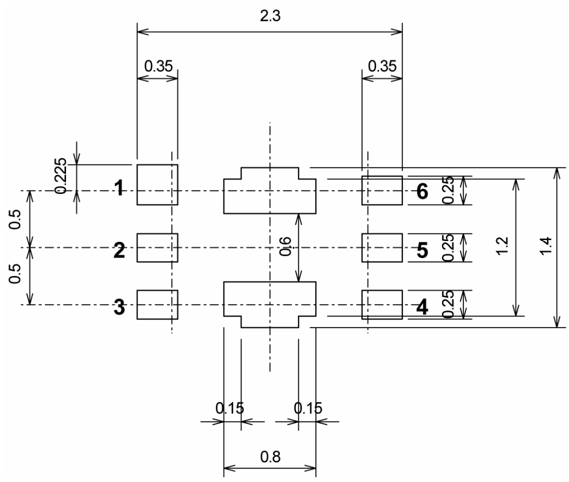
●USP-6B Recommended Metal Mask Design



●USP-6C Recommended Pattern Layout

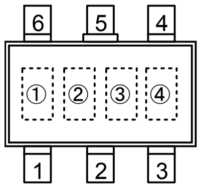


●USP-6C Recommended Metal Mask Design



■MARKING RULE

●SOT-26W



SOT-26W
(TOP VIEW)

①Represents product series

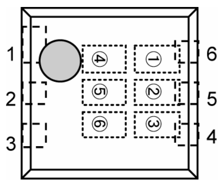
MARK	PRODUCT SERIES
1	XC6401xxxxMx

②③Represents internally set sequential number
ex.)

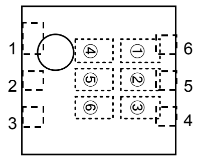
MARK		INTERNALLY SET SEQUENTIAL NUMBER	PRODUCT SERIES
②	③		
C	2	C2	XC6401EED5
C	0	C0	XC6401EED6
0	1	01	XC6401FF36
1	8	18	XC6401FF37

④Represents production lot number
0 to 9, A to Z reverse character 0 to 9, A to A repeated (G, I, J, O, Q, W excepted).

●USP-6B,
USP-6C



USP-6B
(TOP VIEW)



USP-6C
(TOP VIEW)

①Represents product series

MARK	PRODUCT SERIES
1	XC6401xxxxxx

②Represents type of VR1 regulator

MARK	OPTIONAL FUNCTIONS	PRODUCT SERIES
B	EN1: High Active with no pull-down resistor	XC6401Bxxxxx
E	EN1: High Active with pull-down resistor, High speed	XC6401Exxxxx
F	EN1: High Active with no pull-down resistor, High speed	XC6401Fxxxxx
Z	EN1: Low Active with pull-up resistor, High speed	XC6401Gxxxxx
H	EN1: Low Active with no pull-up resistor, High speed	XC6401Hxxxxx
K	EN1: High Active with pull-down resistor, Low power consumption	XC6401Kxxxxx
L	EN1: High Active with no pull-down resistor, Low power consumption	XC6401Lxxxxx
M	EN1: Low Active with pull-up resistor, Low power consumption	XC6401Mxxxxx
N	EN1: Low Active with no pull-up resistor, Low power consumption	XC6401Nxxxxx

③Represents type of VR2 regulator

MARK	OPTIONAL FUNCTIONS	PRODUCT SERIES
B	EN1: High Active with no pull-down resistor	XC6401xBxxxx
E	EN1: High Active with pull-down resistor, High speed	XC6401xExxxx
F	EN1: High Active with no pull-down resistor, High speed	XC6401xFxxxx
Z	EN1: Low Active with pull-up resistor, High speed	XC6401xGxxxx
H	EN1: Low Active with no pull-up resistor, High speed	XC6401xHxxxx
K	EN1: High Active with pull-down resistor, Low power consumption	XC6401xKxxxx
L	EN1: High Active with no pull-down resistor, Low power consumption	XC6401xLxxxx
M	EN1: Low Active with pull-up resistor, Low power consumption	XC6401xMxxxx
N	EN1: Low Active with no pull-up resistor, Low power consumption	XC6401xNxxxx

④⑤Represents VR output voltage (serial number ex.)

MARK		OUTPUT VOLTAGE		PRODUCT SERIES
④	⑤	VR1 (V)	VR2 (V)	
0	1	2.85	2.10	XC6401xx01xx
0	2	2.85	2.85	XC6401xx02xx

⑥Represents production lot number
0 to 9, A to Z repeated (G, I, J, O, Q, W excepted)
Note: No character inversion used

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